Changing Patterns in Air Quality in Teplice, Czech Republic: Effects of Mitigation

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Abstract

Air pollution monitoring was initiated in Teplice and Prachatice, two cities in the Czech Republic, in 1992 as part of a joint project involving the U.S. Environmental Protection Agency (U.S. EPA) and the Czech Ministries of Public Health and the Environment. Teplice and Prachatice were chosen for long-term study because the area surrounding Teplice was highly industrialized and polluted, and Prachatice was located in a much less polluted, rural area. Although this joint air pollution health outcome study ended officially several years ago, monitoring has continued. Since 1995, the same sampling and analytical methods, and quality assurance/quality control procedures have been used in both cities. These efforts are supported by receptor modeling studies to determine major air pollution sources. As a result of this collaborative study, all major air pollution sources have either been closed or have had controls installed, and most residences have switched to cleaner energy sources for heating. These controls have been responsible for a dramatic decline in airborne particle concentrations measured at the monitoring site in Teplice. However, recent increases in the price of natural gas compared to the more traditional solid fuels have caused shifts back to the use of solid fuels for home heating. As a result, air quality has deteriorated in many neighborhoods. In addition, entry into the European Union (EU) has resulted in increases in motor vehicle traffic throughout the country. These factors are all reflected in the data, and ongoing collaboration addresses these emerging issues. These changes have most likely resulted in changes in exposure patterns and thus require an evaluation of the effects of these changes on health outcomes.

Introduction

In many parts of Europe and Asia burning coal for residential heating has resulted in extremely high levels of sulfur dioxide (SO_2) and particulate matter (PM). Residential coal burning was one of the main activities that produced the extremely high pollutant concentrations (~ 2,000 µg/m³ for SO_2 and British smoke, an indicator of combustion derived PM) that characterized the London smog episode that occurred in December, 1952 and resulted in at least 4,000 excess deaths during that period. In Teplice, PM_{10} levels exceeded 1000 µg/m³ during at least one episode in February 1993 (Stevens et al., 1997; Pinto et al., 1998). In addition to burning lignite in hand fired stoves in homes for heating and in power plants, industrial sources and motor vehicles also contributed to the high PM levels that were observed. The challenge in such a situation is to determine the relative contributions of PM sources. In the early 1990's, Teplice was chosen as the site of a joint U.S. EPA – Czech Ministry of Public Health and Ministry of the Environment to determine sources of air pollutants so that effective control measures could be implemented and to evaluate the health effects resulting from these high air pollution levels.

Since the mid 1990's, efforts have been made to reduce pollutant emissions in the region based in large measure on results from the above study. Government sponsored programs were initiated to reduce emissions from small hand-fired coal stoves used for home heating and from power plants in the region. The use of natural gas for residential heating has been promoted by government sponsorship of the purchase of gas furnaces by home owners. Local power plants have also reduced their emissions through air pollution controls.

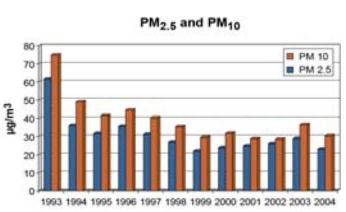

Figure 1

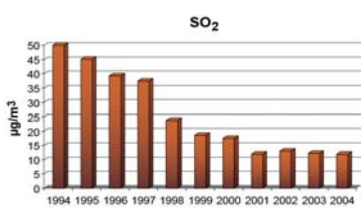

Figure 2

Approach

In addition, to equipment already in use as part of the Czech Hydrometeorological Institute network for monitoring the criteria pollutants (PM; SO_2; carbon monoxide, CO; nitrogen oxides, NO and NO_2; and ozone, O_3) the EPA supplied equipment to measure $PM_{2.5}$ and PM_{10}, trace elements (including heavy metals); and various toxic organic compounds (such as polycyclic hydrocarbons, PAHs) also in PM. These $PM_{2.5}$ and PM_{10} samples were collected with a modified dichotomous sampler (Stevens, et al., 1993) manufactured by URG Inc., Chapel Hill, NC.

The contributions of different sources to PM samples were determined by receptor modeling so that health effects might be attributed to specific types of sources and so that the most efficient controls could be applied to curb emissions. Samples were collected to characterize the composition of emissions from the major expected sources in the area, namely power plants, coal furnaces in homes, motor vehicles and various industries. The composition of these samples was then compared to ambient samples to determine the relative contributions from different sources. The results of these analyses indicated that small furnaces in homes were playing a disproportionately large part in causing air quality to deteriorate.

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Discussion of Results

Due to efforts from government sponsored programs, marked declines in $PM_{2.5}$ and PM_{10} concentrations have resulted as shown in Figure 1. Although these reductions are marked, it should be noted that pollutant levels are still well above those in the United States. By comparison with the average $PM_{2.5}$ concentrations shown here, the annual mean across the United States was about 13 µg/m³ from 1999 through 2001 and the annual air quality standard is set at 15 µg/m³. SO_2 concentrations declined even more than those for $PM_{2.5}$ and PM_{10} as shown in Figure 2. The declines in PAHs, in particular the carcinogenic PAHs are shown in Figure 3.

However, since the early part of this decade, there have been sharp increases in the price of natural gas. As a result, many home owners have gone back to burning solid fuels, including coal, resulting in the slight upward movement in PM levels at the end of the record. Concurrent with the phase out of residential coal furnaces, increases in personal income have led to higher volumes of motor vehicles. This has resulted in an increase of ozone as shown in Figure 4. The causes of changes in CO concentrations shown in Figure 5 are not clear, and likely reflect changes in pollution sources such as home heating and motor vehicle traffic.

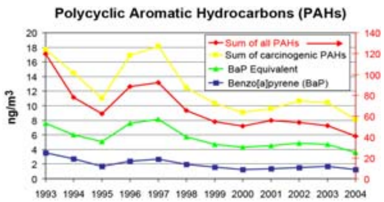

Figure 3

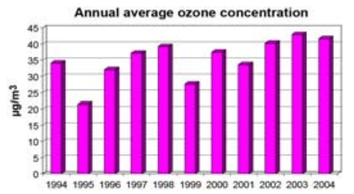

Figure 4

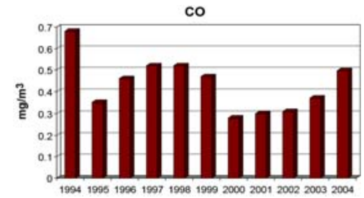

Figure 5

It should be noted that concentrations of pollutants can vary throughout the city. Thus residents can be exposed to either higher or lower concentrations than shown in the figures depending on local sources (traffic, home heating). Measurements of $PM_{2.5}$, its elemental composition, PAH´s, VOC´s, formaldehyde and mutagenicity (Ames test) have also been made in various locations throughout Teplice and surrounding areas as part of indoor-outdoor monitoring for sampling periods of 10 to 12 consecutive days each in 20 indoor and outdoor sites during different seasons from 1995 to 2002 by the Czech Ministry of Public Health. The indoor measurements were made in flats, chosen on the basis of differences in ventilation, and cooking and smoking history. The increase in winter-time $PM_{2.5}$, Benzo [a] pyrene concentrations and the spatial variability in their concentrations are consistent with an increase in contributions from home heating and other localized sources.

Significant sources of indoor air pollution remain. Smoking results in high concentrations of $PM_{2.5}$ and associated pollutants in indoor air. Open fireplaces installed in many homes and the transport of products of combustion of solid fuels from nearby homes were also significant sources of indoor mutagenicity in non smokers' homes. Coal burning is a significant source of both Pb and BaP. Indoor and outdoor levels of Pb and BaP were sometimes higher at the homes of non-smokers, supporting the notion that infiltration of outdoor air was causing deterioration of air quality in non-smokers homes. The table below shows average indoor and outdoor concentrations for samples collected from 2000 to 2002.

	BaP (ng/m³)	Pb (ng/m³)
Smokers I/O	4.0/2.9	25/31
Non-smokers I/O	1.9/3.5	28/50

Studies in the former East Germany found decreases in the incidence of childhood respiratory disease associated with declines in total suspended particulate matter (TSP) and SO_2 (Kramer et al., 1999; Heinrich et al., 2000). These studies were conducted during periods when airborne total suspended particulate and SO_2 levels declined by about 20%. However, current concern focuses on the role of fine particles and on PM components in addition to SO_2. Air pollution-health effects studies in locations where there have been dramatic changes as shown in Figures 1 and 2 are rare, but have played a very important role in developing our understanding of the relations between air pollution and health effects (e.g., Pope et al., 1992; Ransom and Pope, 1992). It may be expected that the large declines in air pollutants resulted in substantial health benefits. However, these benefits have not been characterized and quantified in Teplice. The observed rapid large changes in pollutant concentrations and changes in the composition of pollutant mixtures provide a unique opportunity for investigating health effects related to air pollution.